# Development of Cloud Liquid Water database using Global Cloud-system Resolving Model for GPM/DPR Algorithm


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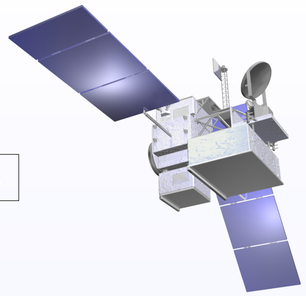


## Uncertainty of cloud in precipitation radar algorithm

- Cloud liquid water (CLW) in precipitating clouds can influence estimates in a precipitation radar algorithm, and attenuation by the CLW should be considered in algorithms of KaPR onboard GPM core observatory.
  - The attenuation due to CLW is severer at the Ka-band than at the Ku-band (e.g., Meneghini and Kozu 1990).
- In 2A25 algorithm for Ku-band Precipitation Radar onboard the TRMM satellite, the attenuation by CLW is estimated based on the result of a numerical simulation of storms with a cloud-system resolving model (CRM) (Iguchi et al. 2009).
  - In the method, the attenuation due to CLW is estimated as a function of surface rain rate (SRR), separately for convective columns and stratiform columns.

## Purpose of this study

- GPM/DPR flies over 65S-65N coverage.
  - We have to collect more CLW database for the GPM than for the TRMM.
- Recently, a 3.5km-mesh global simulation has been performed using a NICAM by JAMSTEC & Univ. of Tokyo.
  - The NICAM is a global cloud-system resolving model (GCRM) (Satoh et al. 2014) , and explicitly calculates moist convection using a cloud microphysical scheme, NSW6 (Tomita et al. 2008).
- In this work, we investigate attenuation by cloud liquid water (CLW) in precipitating cloud from NICAM simulations (Hashino et al. 2013).
  - Data period: 3 hourly data during 9 days from 12Z 16th to 00Z 25th 2008.
  - We have to be careful of considerable model-to-model disagreement in liquid water path, as reported in Li et al. (2008).

## Summary

- CLW database using the global CRM (NICAM) data is developed for attenuation correction method of the GPM/DPR algorithm.
- In this work, CLW and $PIA_{CLW}$ are estimated from the NICAM data 9 days on June 2008.
  - Overall, linear relationship between the surface rain rate (SRR) and the $PIA_{CLW}$ at surface is found for the convective rain, while the relationship becomes much weaker for the stratiform rain.
- Vertical profiles of the CLW are classified with reference to rain types, SRR, latitudes, surface types, and temperature.
  - In the Tropics such as 10S-10N, clear peaks are found around 10-15 degrees Centigrade with small SRRs, while they are not found over the mid-latitude. This can be connected with shallow rainfall.
- Experiments of CLW uncertainty using DPR-L2 algorithms
  - Impacts of Ku product are small (< 2.5 %) and those of Ka products are relatively large (some places > 20%)

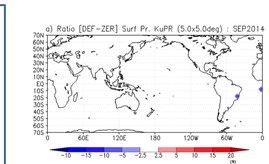
## Experiments using DPR-L2 algorithms

Experiments of CLW uncertainty using DPR-L2 algorithms (algorithms for V03B product)

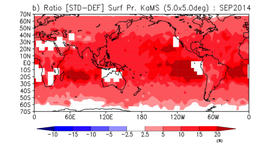
DEF: use average CLW profiles
STD: use average+STD CLW profiles

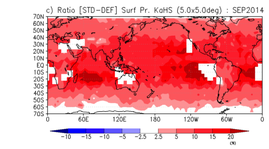
Surface precipitation rates were calculated during Sep. 2014 (1-month)

Ratio = (STD-DEF)/DEF (%)



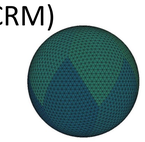

*Impacts of Ku product are small (< 2.5 %) and those of Ka products are relatively large (some places > 20%)*




## NICAM: A global cloud-system resolving model (GCRM)

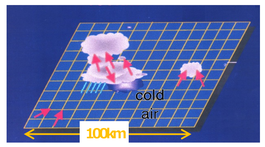
"Global cloud-system resolving model"
NICAM :Nonhydrostatic ICosahedral Atmospheric Model



Development by JAMSTEC & Univ. of Tokyo

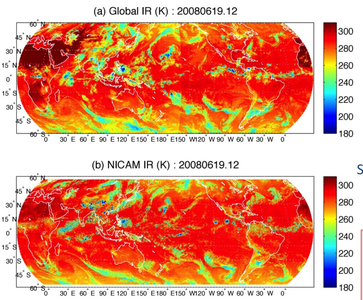
Icosahedral grid structure to achieve Quasi-uniform very high resolution

The Earth Simulator




Direct calculation of cloud system by km-grid mesh covering the Earth

## Validation results of the NICAM compared to the satellite data : Geostationary satellite




Observation
IR 10.8 μm TB [K]

Simulation (NICAM & Joint-Simulator)
IR 10.8 μm TB [K]

**Evaluation by CloudSat and CALIPSO (Hashino et al. 2013, *JGR*) :**

NICAM data reproduced overall cloud characteristics well, although biases were present in the upper layers.

(By Hashino et al. 2013)

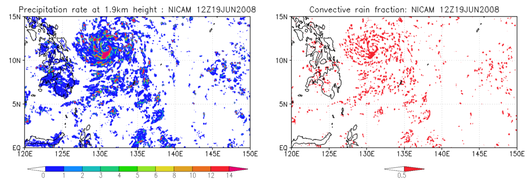
## Classification of convective and stratiform rain in the NICAM data

- Convective and stratiform rain is classified by Nasuno and Satoh (2011), based on that of Churchill and Houze (1984) with modifications proposed by Tao et al. (1993).

Example of convective/stratiform rain classification

Precipitation rate at 1.9km height

Convective rain area diagnosed by the current method

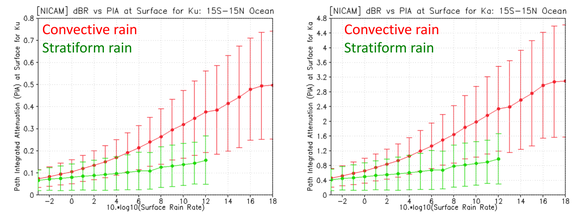



## PIA by CLW from NICAM data: Ku vs Ka

Dependence of $PIA_{CLW}$ at surface upon SRR over tropical (15S-15N) ocean averages with STD bars

Ku-band (13.6GHz)

Ka-band (35.55GHz)

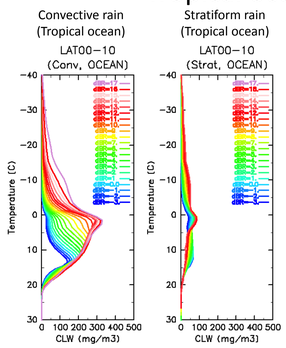



*-3 in dBR = 0.5mm/hr, 0 in dBR = 1.0mm/hr, 10 in dBR = 10mm/hr, 20 in dBR = 100mm/hr*

## Statistics for vertical CLW profiles

- The CLW profiles in the NICAM are classified by
  - surface rain rate (SRR)
    - collected according to a unit of dBR (10 x log10 (SRR))
  - convective/stratiform rain
  - temperature
    - CLW can highly depend upon temperature profiles including freezing level (FL)
  - surface type (land or ocean)
  - latitudes
    - 7 latitudinal zones without distinction of the hemisphere (EQ-10 deg., 10-20 deg. 20-30 deg., 30-40 deg., 40-50 deg., 50-60 deg., 60-90 deg.)

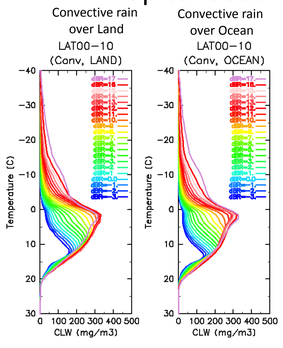
## Profiles with Conv. vs Strat over Tropical ocean




Cloud liquid water content (CLWC) with reference to surface rain rates over tropical ocean (10S-10N).

- The maximum CLWC values are found just below the 0℃ for stronger SRRs.
- For small SRRs, peaks are found around 10-15 degrees Centigrade.

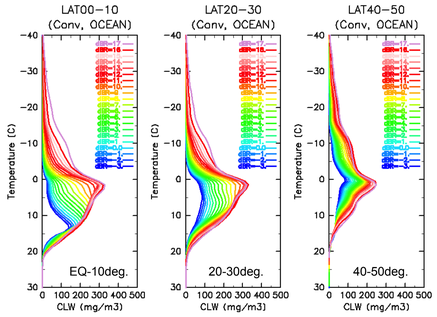
## Profiles for Conv. over Tropical ocean vs. land




Cloud liquid water content (CLWC) with reference to surface rain rates over tropical ocean or land (10S-10N).

- Land/Ocean differences are not so distinct.

## Profiles for Convective over ocean




*Profiles are quite different for latitudes.*